CALIPSO, CloudSat, CERES, and MODIS merged product

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1. Introduction

We will provide the first integrated data set for global vertical profiles of aerosols, clouds, and broadband radiative fluxes using the combined NASA A-train data from Aqua CERES broadband flux data, MODIS passive imager aerosol and cloud data, CALIPSO active lidar aerosol and cloud data, and the CloudSat active radar cloud data. These new data will provide unprecedented ability to test and improve global cloud and aerosol models, to investigate aerosol direct and indirect radiative forcing, and to validate the accuracy of global aerosol, cloud, and radiation data sets especially in polar regions and for multi-layered cloud conditions.

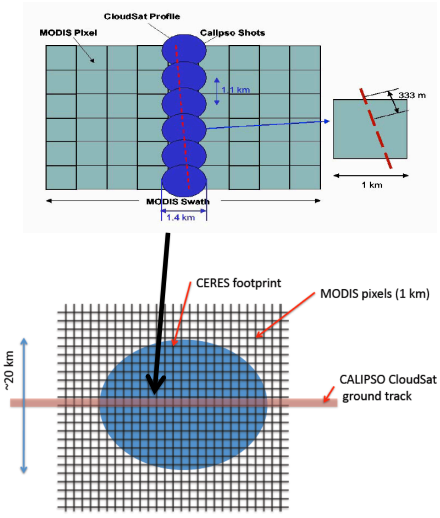


Figure 1: Schematic diagram of CALIPSO and CloudSat profiles merging into MODIS pixels (top) and CALIPSO, CloudSat and MODIS merging into a CERES footprint.

2. Merging cloud mask

Table 1: Cloud Mask Merging Strategy

Cloud boundary	CALIPSO	CloudSat	Merged Cloud boundary
Top	Detected	Detected	Higher cloud top
Top	Detected	Undetected	CALIPSO cloud top
Top	Undetected	Detected	CloudSat cloud top
Base	Not attenuated	Undetected	CALIPSO cloud base
Base	Not attenuated	Detected	CALIPSO cloud base
Base	Attenuated	Detected	CloudSat cloud base
Base	Attenuated	Undetected	CALIPSO lowest unattenuated base

Reference: Kato, S., S. Sun-Mack, W. F. Miller, F. G. Rose, Y. Chen, P. Minnis, and B. A. Wielicki, 2009; Relation of Cloud Occurrence Frequency, Overlap, and Effective Thickness Derived from CALIPSO and CloudSat Merged Cloud Vertical Profiles, submitted to the *J. Geophys. Res.* CALIPSO special issue.

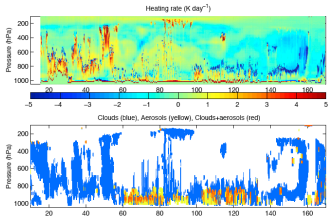
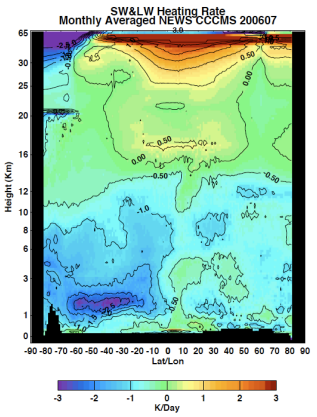


Figure2: Quick overview of the product. Instantaneous heating rate profile (top) and cloud and aerosol mask (bottom)

3. Hearting rate and clouds radiative effects



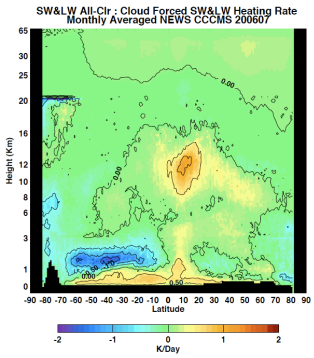


Figure4: Day + night heating rate computed for 120 m layers below 3km, 240 m from 3 km to 21 km, 480 m from 21 km to 33 km, 3000m from 33 km to 45 km, and 5000 m from 45 km to 65 km.

4.Comparison with CERES flux at TOA

CCCM: Irradiances were computed using CALIPSO, CloudSat and MODIS derived clouds and aerosol properties.
CRS: Irradiances were computed using MODIS derived cloud and aerosol properties.

	SW (W m⁻²)		LW (W m⁻²)	
	CCCM-CERES	CRS-CERES	CCCM-CERES	CRS-CERES
200607	4.71	4.84	-0.84	-0.02
200610	6.55	7.05	-1.91	-0.43
200701	5.56	6.53	-2.11	-0.32
200704	5.08	5.57	-1.78	0.37

5. Comparison with surface observations

All fluxes used in the comparison were computed using MODIS derived properties only.

	2002 (28 sites)	2003 (28 sites)	2004 (28 sites)	2005 (28 sites)	2006 (28 sites)
All-sky downward sw model – obs.	10.8	8.9	9.3	8.8	10.4
All-sky downward LW model - obs.	-7.4	-8.5	-8.4	-8.7	-9.0

6. TOA and surface radiation budget from this product

	CERES	CCCM[1]	CCCM scaled[2] (error estimate)
TOA (all-sky)	EBAF(AVG/untune)	CCCM(CRS)	
SW down (W m⁻²)	340.0 (341.3)	488.3 (488.3)	341.3
SW UP (W m⁻²)	99.5 (98.3)	127.4 (127.9)	97.9 (5.9)
OLR (W m⁻²)	239.7 (237.8)	236.9 (238.5)	236.2 (0.8)
NET (W m⁻²)	0.85 (5.2)	124.0 (121.9)	7.2 (6.8)
Surface (W m⁻²)	AVG untune	CCCM (CRS)	
SW down (W m⁻²)	189.0	279.2 (282.9)	186.5 (7.0)
SW up (W m⁻²)	23.1	27.9 (29.3)	22.0
LW down (W m⁻²)	342.2	353.0 (344.1)	350.2 (-8.9)
LW up (W m⁻²)	397.9	404.3 (403.1)	399.1
NET (W m⁻²)	110.2	200.0 (194.6)	115.6

Possible problems in the surface irradiance
1) Cold surface temperature bias over land in GEOS-4.
2) Precipitation screening in CloudSat data.
3) CALIPSO clod mask problem (some aerosols are identified as clouds) below 4 km.

7. Schedule

1) 4 months (July 2006, October 2006, January 2007, and April 2007) are available from Langley ASDC.
http://eosweb.larc.nasa.gov/PRODOCS/ceres-news/table_ceres-news.html
2) Plan to produce nearly 1 year of data by the end of 2009.

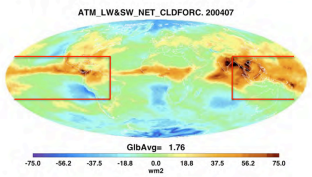


Figure 5: Cloud radiative effect to the atmosphere computed with MOODIS derived cloud and aerosol properties

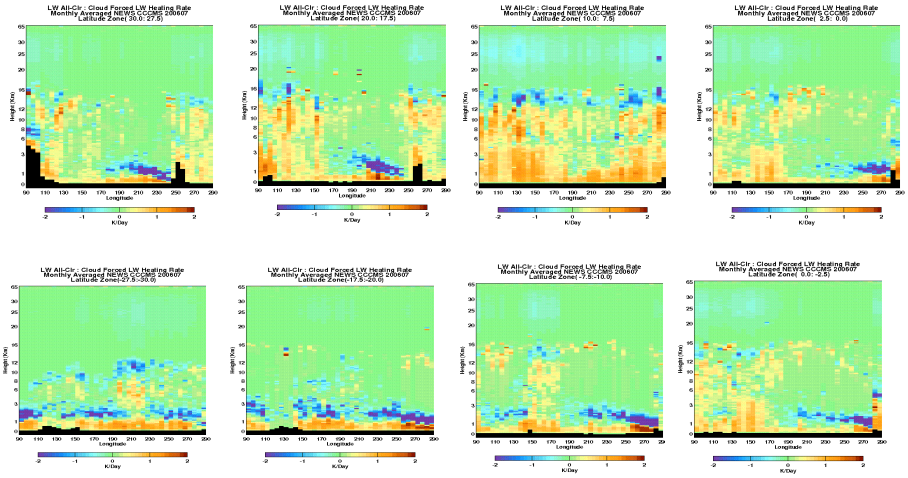


Figure 6: Hearting rate along the longitude in the red box marked in Figure 5 due to longwave computed with CALIPSO, CloudSat , and MODIS.